

## Geographic Research and Applications Subactivity

Program	1999 Estimate	Uncontrol. & Related Chgs.	Program Redirect	Program Changes	FY 2000 Budget Request	Change from 1999
Geographic Research and Applications	38,069	875	-6,385	1,050	33,609	-4,460
Total Requirements \$000	38,069	875	-6,385	1,050	33,609	-4,460

Note: The Program Redirect column reflects the redirection of funds to the Integrated Science, Science Support, and Facilities activities.

### Current Program Highlights

Research activities and investigations conducted under the Geographic Research and Applications Subactivity help advance the understanding of the complex processes that influence the land surface, increase our understanding of the interactions between the physical and human environments, further the applicability of geospatial data and technology, and improve the delivery of information — all vital elements to informed decision making and decision support for the Nation.

In all areas, collaborative research is encouraged with other mapping organizations, academia, and private industry to maximize research resource utilization, promote technology transfer and technological innovations, and enhance understanding and awareness of geographic science throughout the research community. The subactivity also develops systems for collecting, integrating, archiving, and maintaining geospatial data and procures and maintains computer equipment and software for technical infrastructure support for the entire National Mapping Program.

#### ***Increasing Emphasis on Research***

The “Strategic Plan for the National Mapping Division of the U.S. Geological Survey” calls for the National Mapping Program to strengthen its role as the source of USGS expertise in geographic science and applications.

<http://mapping.usgs.gov/misc/strategic.html>

**Geographic, Cartographic, and Information Technology Research** — Through this component, the USGS seeks to improve the understanding of processes on and near the Earth surface, develops more effective and economical methods for making geospatial data available, develops state-of-the-art tools and methods for applying geospatial data to real-world problems, provides these tools to the private sector, and investigates developments in the information technology industry for application in the information management and delivery components of the National Mapping Program. A key aspect of this research is investigation of opportunities for designing, applying, and improving the latest in space-based land remote sensing technology, using data from both government and private satellite remote sensing systems. The USGS also seeks to promote further application of remote sensing technology

by facilitating user access to government technology, by supporting grants to educational and scientific institutions, and by coordinating large- and small-scale applications investigations to improve the overall utility of satellite remote sensing data and technology.

- **Geographic Research** — Geographic research is conducted to better understand the biophysical and socioeconomic processes that influence the land surface and near surface, the ways the land surface functions as a component of the earth system, the response of the land surface to natural and human induced forces, and the use of that understanding for the management of our natural resources. It includes identification, acquisition, development, integration, and application of interdisciplinary information that describes the states and changes of the land surface at regional, national, and global scales; international research and applications; support for other government agencies; global change research; and data collection, assessment, integration, and interpretation for multidisciplinary, multi-agency research activities, such as environmental effects on human health.
- **Cartographic Research** — Cartographic research is conducted to develop advanced analytical methods and spatial data integration tools required to design, create, and maintain national data bases compatible with the NSDI national geospatial data framework. Current investigations are focused in two broad areas:
  - Develop geospatial data handling methods and techniques to allow for the integration, revision, and certification of large holdings of all types of geospatial data (vector, raster, image, terrain, names, etc.),
  - Develop and describe measures, collection processes, and testing procedures for components of spatial data quality, such as logical and topological consistency, completeness, positional accuracy (horizontal, vertical, and radiometric), and attribute accuracy.
- **Information Technology Research** — Information technology research investigates emerging information access, delivery, and analysis technologies and standards and assesses their potential for archiving and dissemination of geospatial data. The focus is on implementation compatibility with the NSDI national geospatial data framework.

In recognition of the increasing importance of geospatial data interpretations and application capabilities to help solve societal problems, the “Strategic Plan for the National Mapping Division of the U.S. Geological Survey” calls for the National Mapping Program to strengthen its role as the source of USGS expertise in geographic science and applications. Toward this end, the NMP is increasing emphasis on geographic science activities, and particularly on geographic research activities designed to improve the understanding of processes on and near the land surface and to incorporate geographic information and tools into decision support capabilities useful for addressing near- and long-term problems. Key areas of research include:

- **Geography and Environmental Effects on Human Health** — From tracking the spread of the winter flu season to pinpointing outbreaks of the Ebola virus, human health issues are geographic issues as well. USGS scientists are collaborating with colleagues in the health

profession to bring the tools of remote sensing and geographic analysis to bear on problems of human health. The USGS has begun a program of joint research with the National Center for Infectious Diseases (one of the Centers for Disease Control and Prevention) to use geographic methods and digital geospatial data in analyzing the spatial distribution of various diseases. This analysis will determine where geographic patterns exist and whether such patterns are correlated with factors in the physical environment. Initial studies focus on lyme disease, plague (see Figure NMP-4 showing cases of plague reported in the Four Corners area since 1960), and La Crosse encephalitis.

### **Bringing the Tools of Geographic Analysis to Bear on Human Health Problems**

**Insert NMP Fig 4. near here**

[Cases of plague reported in the Four Corners area 1960-1997.]

Figure NMP-4. Spatial analysis of health data using geographic information systems improves understanding of the geographic distribution of disease outbreaks (stars). The resulting geographic patterns can be compared with other factors in the physical environment (shaded background).

- **Monitoring Global Land Cover Characteristics** — To support informed decision making about the effects of land surface processes on the environment, the USGS is documenting

the geographic variability of global land cover and land use using state-of-the-art remotely sensed data and classification strategies. In addition, modeling techniques are being developed to explain the associated differences in land management, productivity, and seasonality that are relevant to future global environmental conditions. Specific questions that are being addressed include: (1) What is the extent of human modification of the natural environment? (2) How does this affect key economic issues including weather formation, storm behavior, wildfire hazards, and atmospheric chemistry? (3) What types of land cover are most dynamic and how do these changes affect potential for compliance with international environmental treaties (i.e., biodiversity, climate change)? (4) What are the regional rates of change in land cover and land use change, and what are the social, economic, and environmental driving forces of these changes?

- **Analysis of Land Use Change in Urban Environments** — The USGS Urban

Dynamics program is establishing a retrospective mapping data base and prospective modeling tools for the super-metropolitan regions of greater New York City, Chicago-Milwaukee, Philadelphia-Wilmington, and Portland-Vancouver while continuing to apply results obtained

from earlier research in the San Francisco-Sacramento and Washington-Baltimore metropolitan areas. Building upon past and ongoing research in mapping urban land use change, the USGS is conducting a geographic assessment of the spatial patterns, rates, and trends of land use change in the Washington, D.C. and Albuquerque, NM metropolitan areas as they relate to social, economic, demographic, and physiographic parameters. This research is designed to enhance urban growth modeling and predictive tools to identify trends, linkages, and causal relationships between land use change and hydrologic and biologic phenomena. These tools will permit urban and regional planners to more accurately model and predict likely environmental impacts of alternative development scenarios.

***Modeling the Impact of Development***

Urban growth modeling and predictive tools are being enhanced to permit urban and regional planners to more accurately model and predict likely environmental impacts of alternative development scenarios.

- **Water and Sediment Transport on Landscapes of the Southwest** — Recent research conducted in the Rio Puerco basin has resulted in development of analytical tools useful for modeling the flow of water across uplands and through channel systems and the resulting patterns and processes of erosion and deposition. USGS scientists are building upon these initial results to refine the model and improve the understanding of the coupling of processes that foster the Rio Puerco's extensive and periodic erosion. Because of the potential of this work for application in the study of flash floods, the USGS is applying equivalent techniques in other regions of the Southwest, in collaboration with a new Flash Flood Laboratory (members include NOAA, Colorado State University, and the University of Colorado). Particular emphasis is being placed on modeling flash flood hazards in urban environments of the Southwest, where flash floods cause the greatest losses of life and property. Web site: [http://climchange.cr.usgs.gov/rio\\_puerco/](http://climchange.cr.usgs.gov/rio_puerco/).
- **Land Resources Observation Studies** — When the Landsat 7 and the EOS AM-1 satellites are launched (both are scheduled in 1999), a wide variety of new data products will become available to the user community for the first time. Data from the sensors

onboard these platforms will be useful for measuring and monitoring a wide array of land resources phenomena, such as volcanic activity, flooding, vegetation mapping, geologic assessment, fire fuel potential, and land cover change such as deforestation. In preparation, USGS scientists are designing radiometric and geometric characterization and calibration analyses which will enhance the utility and usefulness of the data. In addition, applications-oriented studies are being designed to determine and demonstrate the level of usefulness of the data for monitoring, assessing and managing the Earth's natural resources.

- **Decision Support Systems** — The USGS is developing a conceptual model of the high-level architecture necessary for a decision support system useful for addressing terrestrial resource management, disasters and hazards, and other Earth surface issues. Knowledge concerning the role of the land surface is a critical environmental factor. Consequently, computer-assisted techniques to apply this knowledge are vital for effective land management, the preservation of biological diversity, and the development of adaptation and mitigation strategies related to the management of sensitive lands. An improved understanding of the role of natural science information in public and private decision making is needed as technology evolves and as societal issues become increasingly complex.
- **International Research and Applications** — This program specializes in projects that use remotely sensed data or geographic information systems to address issues of sustainable development, resource management, land cover change, monitoring, and early warning systems in many countries around the world. Projects are developed based on specific requests from other U.S. agencies, non-government organizations, international donors, or host countries. An example application is the Famine Early Warning System (FEWS). FEWS has been developed over several years in cooperation with NOAA and NASA under the sponsorship of the USAID to utilize remote sensing techniques for monitoring rainfall and vegetation conditions across Africa. This information provides decision makers in affected countries with timely and accurate information on potential famine conditions which can be used to determine appropriate intervention strategies. Web site: <http://edcintl.cr.usgs.gov/ip/ip.html>.
- **Global Change Research** — The Geographic Research and Applications Subactivity supports the multi-agency U.S. Global Change Research Program (USGCRP) by: (1) developing and applying complex data sets and descriptions of land characteristics to understand and model land processes and land-atmosphere interactions; and (2) enhancing and applying technology for monitoring, analyzing, and predicting rates, patterns, and impacts of landscape changes resulting from natural and human causes. The diverse USGS efforts in support of the USGCRP include providing spatial analysis in support of the USGS Mississippi Basin Carbon and Rio Puerco River Basin projects, and analyzing remotely sensed data in support of the Circumpolar Arctic Vegetation Mapping initiative. Techniques are being developed for (1) modeling land use change at the regional and continental scale, (2) assessing the sensitivity of terrestrial systems to human and climate induced impacts, and (3) evaluating the application of land use and cover, soils, and elevation and derivative data for improving the land component of multi-component terrestrial process models. Other efforts are underway to develop unique

applications of the Global Land Cover Characteristics Data Base and improve the characterization of global agriculture and forestry land uses.

The USGS also is supporting regional and sectoral assessments of the consequences of climate variability and change as part of the National Assessment of the Consequences of Climate Variability and Change for the United States (the "National Assessment"), which is sponsored by the Office of Science and Technology Policy and the USGCRP. USGS is responsible for regional assessments in Alaska, the Southwest, and the Great Basin/Rocky Mountains, and a sectoral assessment looking at water resources nationwide. In addition, the USGS is providing overall coordination of the Department of the Interior's responsibilities in the National Assessment and is providing research and applications assistance to other participating agencies. Web site: <http://www.nacc.usgcrp.gov/>.

- **USGS Center for Integration of Natural Disaster Information (CINDI)** — The USGS Center for Integration of Natural Disaster Information is a research facility for (1) developing and evaluating technology for information integration and dissemination, (2) performing research in data integration, analysis, modeling, and decision support, and (3) supporting the ongoing evolution of the USGS processing and delivery of hazards data. Priorities for the data integration research activities of the CINDI include processing near-real-time data from multiple sources (such as instrument networks, derived products from classified sources, public satellite data, and standard USGS information products) and data covering the entire nation. Research results are used in the development of applications and tools that will help citizens, local and State officials, and Federal managers use scientific observations to make well-informed decisions. Web site: <http://cindi.usgs.gov/events/index.html>.

**Information Systems Development and Maintenance** — Through this component, the USGS (1) develops systems for collecting, integrating, archiving, and maintaining geospatial data and (2) procures and maintains computer equipment and software and ensures the continued effective operation of the National Mapping Program technical infrastructure at offices nationwide to enable the program to provide information and technical application prototypes to the Nation. Specific activities include the operation, maintenance, design, development, expansion, enhancement and acquisition of geographic information systems, digital cartography, image processing, information management and business computer systems and digital telecommunications networks utilized nation-wide for accomplishment of the NMP. This activity also provides support for systems issues within the Department of the Interior (including NMP compliance with Y2K requirements) as well as across the Federal Government, coordinating with the private sector, and with academia.

The systems development activity has historically depended upon internal government staff for most of the systems integration work and much of the unique software development required to support the NMP. However, there has been dramatic growth over the past several years in the breadth of commercially available software with advanced mapping and information management functions. Emphasis has accordingly been shifted to employing and adapting more commercial-off-the-shelf solutions and to developing stronger partnerships with the private sector to meet NMP systems and software needs.

## Recent Accomplishments

**USGS and Partner Agencies Study Hurricane Mitch** — The USGS, NOAA, and the Environmental Systems Research Institute, Inc. collaborated in an around-the-clock effort to produce a series of products to aid emergency response during the period immediately following the devastating landfall of Hurricane Mitch in Central America. The primary product is a collection of GIS data layers for Central America. These data layers can be combined in various ways to produce customized maps helpful to relief agencies and organizations responding to this disaster (see Figure NMP-5 showing Honduras Landslide Susceptibility map from online Central America Disaster Atlas). Through the USGS research facility Center for the Integration of Natural Disaster Information, the bureau is providing the Central America GIS database on CD-ROM to the USAID and the Army Corp of Engineers, as well as to counterparts in the affected countries. Additional products include a "Central America Disaster Atlas" and a "Central America Disaster Overview." Additional information and resources were contributed by NASA, the National Imagery and Mapping Agency, Medea, EarthSat, Silicon Graphics, Inc., and Microsoft. Web site: [http://cindi.usgs.gov/events/mitch/cent\\_amer.html](http://cindi.usgs.gov/events/mitch/cent_amer.html).

### **USGS Scientific Expertise, Information, and Data Integration Aid Hurricane Mitch Relief Efforts**

**Insert NMP Fig 5. near here**  
[Honduras Landslide Susceptibility.]

Figure NMP-5. Example of the type of geospatial information provided by the USGS immediately following the devastating landfall of Hurricane Mitch in Central America during October-November 1998. Integrated data products and analyses, such as this depiction of

landslide susceptibility, aided international emergency response efforts. Other products, such as multiple GIS data layers, were provided that can be used to produce customized maps for specific purposes.

**Urban Growth Modeling Aids Albuquerque Land Use Planning Decisions** — As part of the 5-year Middle Rio Grande Basin Study to improve the understanding of the hydrology, geology, and land-surface characteristics of the Middle Rio Grande Basin, USGS scientists are analyzing the population growth, urban spread, and other land use changes in the Albuquerque region to identify potential impacts to water availability resulting from either increased demand or decreased recharge area. Building upon the experience gained from past work in temporal urban mapping and urban growth modeling, land use and land cover data collected for four time periods have been combined with newly developed regional slope data in a regional urban growth model to predict areas of potential future urbanization in the Albuquerque region. The urban growth predictions will be combined with results of hydrologic and geologic studies in a decision support system to help regional land and water managers to analyze the impact of land-use planning decisions on water supplies and to investigate alternative scenarios to meet expanding water needs. Web sites:

<http://edcwww2.cr.usgs.gov/urban/> and

<http://rmmcweb.cr.usgs.gov/public/mrgb/mrgbhome.html>.

**Inundation Mapping and Flood Analysis Tested in New Classified Facility** — In a cooperative effort with the U.S. Army Corps of Engineers, USGS researchers conducted a pilot project during FY 1998 to evaluate and demonstrate the use of remote sensing data from classified systems in a collateral facility (Secret-level classification) for inundation mapping and flood analysis. The project was sponsored by the Environmental Intelligence and Applications Program (EIAP) under the auspices of the CIA's Office of Research and Development, and involved a Medea scientist from the University of California at Santa Barbara. Utilizing Secret-level remote sensing data collected several

days after the peak of a flood in January 1997 around the city of Modesto, California, researchers were able to accurately delineate the maximum extent of the inundation along the flood plain by examining geomorphic and hydrologic signatures left by the flood waters. Results were verified by comparing findings with conventional aerial photography. The capability to use classified assets for inundation mapping and flood analysis offers a potentially valuable supplement and alternative to mapping with conventional aerial photography, particularly in emergency situations where conventional photography cannot be acquired in a timely manner due to cloud cover or other adverse conditions. This project was carried out entirely in the new USGS National Center Collateral Facility in Reston, Virginia, one of four collateral facilities established in 1998 to offer USGS and other scientists the opportunity to access and apply the wealth of data and information that has been reclassified in recent years to Secret from higher classification levels. In addition, all processing and data integration work was conducted using standard, commercially available image processing and GIS software

### ***Flood Analysis and Remote Sensing Data***

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and hardware to ensure portability of the processing techniques and compatibility with standard data types derived from non-classified sources.

**Fire Potential Index Model Developed for Mediterranean Climates** — The

Mediterranean climate zone of California is of special importance to fire managers because of the large population adjacent to highly flammable wildlands. To minimize the threat from wildfires, fire managers must be able to plan protection strategies that are appropriate for individual local areas; a prerequisite for this planning is the ability to assess and map fire potential across both broad areas and local sites. To support

such assessments, USGS and U.S. Forest Service scientists have developed a fire potential index (FPI) model tailored for the peculiarities of Mediterranean climate conditions that assesses the probability of occurrence of fire at a 1-kilometer resolution over large areas on a real-time, daily basis. The FPI was initially calculated and successfully validated for the Mediterranean climate zone of California for the period 1990 through 1994. The success of the FPI in this California ecosystem indicates that it is potentially a valuable fire management tool for U.S. land management agencies and for land managers in other countries with Mediterranean ecosystems such as Argentina, Chile, Mexico, and Spain. Web site: <http://edcintl.cr.usgs.gov/ip/firefeature/firepaper.htm>.

***Assessing Wildlands Fire Potential***

The fire potential index model developed for the Mediterranean climate zone of California is a valuable fire management tool for U.S. land management agencies dealing with large populations adjacent to highly flammable wildlands. It also has potential for application by land managers in other countries with Mediterranean ecosystems such as Argentina, Chile, Mexico, and Spain.

**Front Range Infrastructure Resources Management** — As part of the USGS Front Range Infrastructure Resources Project (FRIR), researchers have developed a Group Spatial Decision Support System based on commercial software (SmartPlaces and ArcView) to provide the public and decision makers with objective information about the location and characteristics of land, natural aggregate, water, and energy resources – natural assets that are vital to sustaining this area and its infrastructure. Some of the data types being developed or acquired for use in the system include land use and land cover for four separate time periods, soils, aggregate resources, base geologic data, aquifer extent, oil and gas resources, base cartographic data, and habitat and species information. When analyzed together, these data provide an integrated, composite picture of the characteristics of the land. This system will allow local groups, such as the Denver Regional Council of Governments, to easily view and manipulate geospatial data developed by this project, and assist them in making better-informed decisions affecting land use and development. Web site: <http://webserver.cr.usgs.gov/frirp/FRIRP.html>.

**Long-Term Monitoring of Environmental Change in Senegal** — In partnership with USAID and Senegal's Center for Ecological Monitoring (CSE), USGS scientists have developed a long-term monitoring framework to better understand and document the rapid changes that are occurring in Senegal's natural resources. The monitoring approach has been tested by the project team, and embraced by CSE. It entails a three-tiered approach using the combined strengths of (1) ground site investigations (biophysical and socioeconomic), (2) repetitive airborne videography, and (3) high-resolution satellite remote sensing spanning 35 years. In order to peer into the past and establish a historical baseline on natural resources, USGS and

CSE scientists have tapped into the extensive archive of declassified Corona photographs which provide an invaluable photographic record of the Earth back to 1960 (see Figure NMP-6 of Senegal River Valley Deforestation, 1965 Corona image beside 1992 Landsat TM image). As with many countries in Africa, the Corona archive provides nearly 100 percent coverage of Senegal, at ground resolutions approaching 1.5 meters. These efforts have generated analyses and image and map products that Senegal's environmental policy-makers are using to better understand the rates, magnitudes, and causes of change.

### Senegal River Valley Deforestation

Figure NMP-6. USGS holdings of declassified Corona photographs provide an invaluable historical record of the Earth surface back to 1960. For example, this 1965 Corona image and corresponding 1992 Landsat Thematic Mapper image depict river valley deforestation that has occurred in Senegal.

**Reconstruction of Historical Land Cover for Watershed Analysis and Restoration** — As part of the Urban Dynamics Research Project, USGS scientists completed a spatial reconstruction of historical land cover for the Patuxent River watershed and surrounding area in southern Maryland. GIS spatial modeling and data integration techniques were used in mapping agricultural, forest, and urban land for six time periods between 1850 and 1992. This research is helping the USGS to correlate historical land use changes in the Chesapeake Bay watershed to changes in the ecosystem over several time scales including the last several

decades and the last several centuries. Preliminary findings from the Patuxent study area indicate that deforestation began near 1650 and hit a peak from about 1850-1900. During this time, agriculture accounted for over 80 percent of the land use in the greater Baltimore-Washington area. Agricultural use has decreased since 1900 and is being replaced by urban land use and forest land. The extensive land clearance in the mid-to-late 1800's is also reflected in ecosystem indicators showing large changes in salinity, dissolved oxygen, and sedimentation rates. This information will be valuable in helping to establish restoration goals that accurately reflect changes in the system due to natural variability and historical land-use changes. Web site: <http://edcwww2.cr.usgs.gov/urban/cbay/ag/intro.html>.

**Hardware and Software Replacement Strategy Curbs Rising Maintenance Costs** — The USGS began an effort in FY 1996 to modernize all hardware and software systems supporting the NMP by (1) replacing obsolete, expensive-to-maintain equipment with new equipment that can be maintained at lower costs, (2) utilizing more off-the-shelf, commercial software and less in-house development, and (3) assuring that all systems and facilities are Y2K compliant. Through this strategy, the NMP has been able, over the last 3 years, to reduce hardware maintenance obligations by about \$1 million per year, which has allowed the development of an on-going hardware replacement strategy designed to continue to keep maintenance costs in control. The increased use of off-the-shelf software has reduced overall software maintenance costs and allowed the NMP to re-engineer many of its business practices and accommodate reductions in personnel without major programmatic disruption. Major efforts, both in time and cost, have been directed at making the NMP Y2K compliant with the result that by the end of calendar year 1999 all identified Critical and Essential systems will be certified compliant.

## Justification of Program Change

### Real-Time Hazards (CINDI; +\$0.45 million) —

Immediately after natural disasters such as Hurricane Mitch, considerable scientific analysis is required to understand the effect and dimension of the phenomenon, how best to respond to the variety of existing and potential losses, and how to help with recovery activities. Because of the short time frames available during and after a

disaster, time-critical analytical capabilities must be in place and ready to use before the event occurs. The increase will be used to begin to establish a standing analytical capability in the USGS Center for Integration of Natural Disaster Information (CINDI) to ensure that information from multiple, disparate sources can be integrated and analyzed quickly to provide the synoptic views of on-the-ground conditions and scenarios that are needed in near-real-time by the decision makers and recovery teams responding to disaster events.

	FY 2000 Request	Program Change
\$(000)	33,609	+1,050

**Research and Monitoring for Amphibians as an Indicator Species (+\$0.6 million)** — The proposed increase will support the compilation and analysis of geospatial data to characterize habitat in areas of demonstrated amphibian loss that have been targeted for controlled experiments by USGS biologists and to develop methods to use spatial analytical techniques to predict potential amphibian loss. In particular, geographic analysis and mapping techniques

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will be developed and tested for (1) measuring changes through space and time in amphibian habitat and (2) determining contaminant transport pathways.